CLAIMS

What is claimed is:

1. A non-linear optical system for imaging an object comprising:

optics for focusing and encoding a wavefront from the object to an intermediate image such that an optical transfer function of the optical system, at the intermediate image, is more invariant to focus-related aberrations as compared to an intermediate image formed by the optics without encoding;

a non-linear detector for detecting the intermediate image; and

a linearization processor for electronically capturing the intermediate image.

2. The optical system of claim 1, wherein the optics comprise a phase mask that modifies the optical transfer function of the optical system by affecting phase of the wavefronts transmitted by the phase mask.

3. The system of claim 1, wherein the aberrations include one or more of misfocus, spherical aberration, astigmatism, field curvature, chromatic aberration, temperature induced misfocus aberration, and pressure induced misfocus aberration.

4. The system of claim 1, wherein the non-linear detector comprises film.

5. The system of claim 1, the nonlinear detector having an intensity threshold, wherein any part of the intermediate image that is below the intensity threshold is not detected by the nonlinear detector.

6. The system of claim 1, wherein the optics comprise an optical element with an aspheric phase profile.

7. The system of claim 5, wherein the optical element is positioned at one or more of a principal plane of the imaging system, an image of the principal plane, an aperture stop of the imaging system, and an image of the aperture stop.

8. A system of claim 1, further comprising a post processor for linearizing the electronically captured intermediate image to form a linearized image and for removing effects of wavefront coding induced by the optics to form a final image.

9. The system of claim 7, wherein the post processor linearizes the intermediate image by measuring an exposure curve within an image detected by the non-linear detector and by converting the exposure curve into a substantially linear exposure curve.

10. The system of claim 9, the exposure curve comprising an overexposed region and an underexposed region, wherein any part of an image falling into the underexposed region or the overexposed region is not recorded by the detector.

11. The system of claim 1, the non-linear detector comprising a non-linear digital detector.

12. The system of claim 9, wherein the non-linear digital detector comprises CMOS detector elements and a circuitry to extend dynamic range.

13. The system of claim 9, wherein the non-linear digital detector comprises a digital circuit with different responses for different pixels.

14. The system of claim 9, wherein the non-linear digital detector comprises a digital circuit with detectors having logarithmic response

15. A method for reducing aberrations in a wavefront imaged by an optical system having a non-linear detector, comprising:

encoding a wavefront of electromagnetic radiation from an object imaged to the non-linear detector;

digitally converting data from the non-linear detector to form a digital representation of the image captured by the detector;

linearizing the detected image to form a linearized image; and

filtering the linearized image to reverse effects of wavefront coding to form a final image.

16. The method of claim 13, wherein the step of encoding a wavefront comprises the step of coding the wavefront with a phase mask that modifies the optical transfer function of the optical system by affecting the phase of the wavefront transmitted by the phase mask.

17. The method of claim 13, wherein the step of linearizing the detected image comprises the steps of measuring an exposure curve for the image detected by the non-linear detector and converting the exposure curve into a substantially linear exposure curve.

18. The method of claim 13, wherein linearizing the detected image comprises the step of:

determining the approximate value of the highest density in the image detected by the non-linear detector;

wherein converting the exposure curve into a substantially linear exposure curve comprises:

generating a look up table by solving for integer values on the exposure curve between the approximate highest density value and a low density value; and

mapping the values in the look up table onto the substantially linear exposure curve.

19. The method of claim 13, wherein filtering the linearized image of the wavefront is performed by a filter defined by the Fourier-domain equation:

$$F(\nu, \xi) = \frac{W(\nu, \xi)H^*(\nu, \xi)}{H(\nu, \xi)H^*(\nu, \xi) + \sigma},$$

where F(?, ?) is the filter, W is the ideal diffraction-limited optical transfer function, H is the input data (H* is the complex conjugate of H), and s is the Weiner parameter.

20. The method of claim 13, wherein the aberrations include one or more of misfocus, spherical aberration, astigmatism, field curvature, chromatic aberration, temperature induced misfocus aberration, and pressure induced misfocus aberration.

21. The method of claim 13, wherein the non-linear detector is an analog film.

22. The method of claim 13, wherein modifying the wavefront comprises utilizing a phase mask.

23. A method for reducing aberrations in a wavefront imaged by an optical system having a non-linear detector, comprising:

setting an intensity threshold of the non-linear detector, wherein any part of an intermediate image below the intensity threshold is not detected by the non-linear detector;

encoding a wavefront of electromagnetic radiation from an object imaged to the non-linear detector;

digitally converting data from the non-linear detector to form a digital representation of the image captured by the detector;

linearizing the detected image to form a linearized image; and

filtering the linearized image to reverse effects of wavefront coding to form a final image.